Conserved Quantities in Transport Mode Choices and Mobility Patterns of People

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1 Introduction

The availability of large-scale datasets recording human digital traces has provided novel insights on the quantitative patterns characterizing human movement [1, 2]. While the mechanism for individuals' place visits has long been studied, our understanding of how people travel to reach these places is still limited. In this study, with a high-resolution GPS tracking dataset that records individuals whereabouts for up to 12-month, we analyze the long-term evolution and composition of trips.

2 Data and mobility measures

We used data from a large-scale pilot project that was conducted by the Swiss federal railways (SBB). For the duration of one year, 138 Switzerland-based participants were provided with additional mobility options and were asked to record their whereabout using a GPS-tracking app. Following the work from [2], we define the activity set for each participant containing the places visits at least twice and spent more than 20 minutes/week in 20 consecutive weeks. We further introduce the concept of frequent activity set, containing the places that are always within each individual's activity set.

The individual's distance traveled can be characterized using the radius of gyration, whose distribution can be approximated by a truncated power law [1] (Fig. 1). We observe that our users tend to travel longer distances, which could due to 1) the long-term and world-wide tracking. 2) the study's preconditions causing bias towards high mobility demand. 3) the (nearly) unlimited mobility options provided.

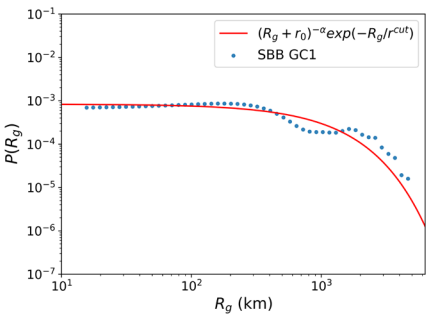

Fig. 1. Radius of gyration distribution with the best fit truncated power law

3 Stability of the activity set

We select participants with high time coverage over the whole study and analyze the proportion of important trips. Using a 20-week sliding window, we calculate the trip count evolution for each individual, and the average over all the participants is shown in Fig. 2. For trips conducted within the activity set, using a linear fit of count proportion against time, we observe that the slope **b** is not significantly different from 0, suggesting that this trip proportion is a conserved quantity over time. However, this stability is not found in the frequent activity set (Fig. 2). The PDF of the frequent activity set is bi-modal, suggesting the existence of two different classes of individuals. Similar results are obtained for distance and duration proportion of important trips.

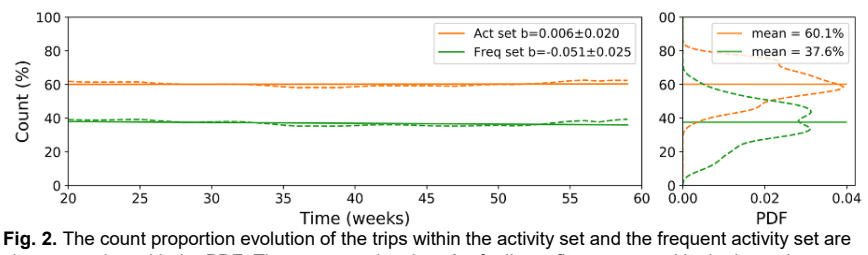

Fig. 2. The count proportion evolution of the trips within the activity set and the frequent activity set are shown together with the PDF. The errors on the slope **b** of a linear fit are reported in the legend.

4 Trip-based mobility package decomposition

On the individual level, the trip set is decomposed into mobility packages via clustering analysis, where each package stands for one type of mobility behavior. We consider travel mode, distance traveled and duration spent as features, and adopt hierarchical clustering with WB-index [3] for choosing the optimum cluster number. By analyzing the evolution of mobility packages, we can delineate user mobility preferences and detect mobility behavior changes (Fig. 3).

Fig. 3. The mobility packages' distance proportion evolution (a), distance-duration scatter plot (b) and average frequency of travel mode (c).

The results also enable comparison among individuals. A user could favor several packages that share comparable proportions (Fig. 4a) or prefer a single mobility package that is superior over all the other (Fig. 4b). A switching of mobility preferences can also be identified (Fig. 4c).

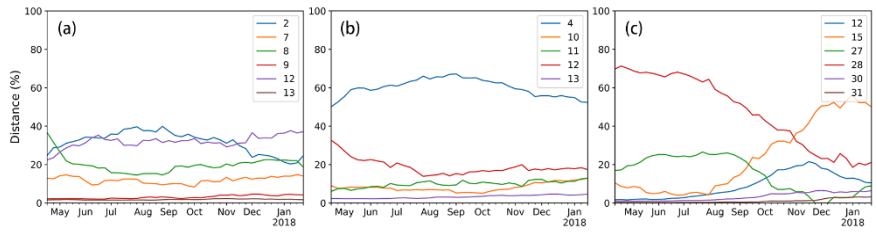

Fig. 4. Distance proportion evolution of mobility packages for different classes of individuals.

5 Conclusion and Outlook

The continuous recorded and semantically enriched GPS dataset provides us access to the spatiotemporal localization and movement of users. In short, our work can be summarized as:

- We conduct an in-depth analysis of the dataset using high-level mobility indicators.
- We provide evidence for the stability of mobility indicators on trips.
- We identify mobility packages to delineate mobility preferences.

This study deepens our understanding on the individual's mobility behavior. In future work, we should verify the trip stability on a bigger dataset and could introduce more semantic features for package decomposition.

6 References

[1] Gonzalez, M. C., Hidalgo, C. A., & Barabasi, A. L. (2008). Understanding individual human mobility patterns. Nature, 453(7196), 779-782.
[2] Alessandretti, L., Sapiezynski, P., Sekara, V., Lehmann, S., & Baronchelli, A. (2018). Evidence for a conserved quantity in human mobility. Nature Human Behaviour, 2(7), 485-491.
[3] Zhao, Q., & Fränti, P. (2014). WB-index: A sum-of-squares based index for cluster validity. Data & Knowledge Engineering, 92, 77-89.